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One-pot embedding of iron oxides and Gd(III) complexes into silica nanoparticles—Morphology and aggregation effects on MRI dual contrasting ability

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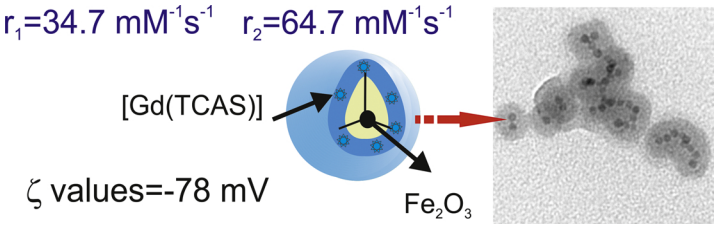
GRAPHICAL ABSTRACT



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ABSTRACT

The present work introduces one-pot synthetic route to join ultra-small iron oxides (6 nm) with Gd(III) complexes in small (~30 nm) silica nanoparticles with high longitudinal and transverse relaxivity values (r_1 = 34.7 $mM^{-1}\,s^{-1}$ and r_2 = 64.7 $mM^{-1}\,s^{-1}$ at 0.47 T). The design of the nanoparticles is based on the core-shell morphology, where the Gd(III) complexes were doped into the exterior silica layer. The doping mode is the reason for an efficient interfacial hydration and the small suppressing of r_1 by iron oxides. The measurements on the whole body scanner at 1.5 T confirm the high contrasting abilities of T_1 (Gd) and T_2 (iron oxide) components in the nanoparticles. Poor aggregation behavior of the nanoparticles in water is due to high electrokinetic potential value (−78 mV). Greater aggregation of the nanoparticles in the buffer solutions of bovine serum albumin enhances the disturbing effect of iron oxides on the longitudinal relaxation and facilitates the transverse relaxation. The higher surface activity of the nanoparticles results in their greater cytotoxicity versus the silica coated iron oxides, although the cytotoxicity is low in the concentration range which is within the region of interest for MRI technique.

1. Introduction

Magnetic resonance imaging (MRI) is one of the most powerful tools of noninvasive medical diagnostics [1–5]. The widespread application of this method requires new contrast agents (CAs) with increased efficiency, and decreased toxicity [6,7]. The nanoparticulate approach has been highlighted as the most efficient tool to gain in both efficiency and non-toxicity of CAs [8–12].

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